Methane and Climate Policy

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Reports and Reprints detailing many of the results discussed can be found at http://web.mit.edu/globalchange/www

Prepared for the IPIECA Workshop: **Natural Gas as a Climate Change Solution:** Breaking down the barriers to methane's expanding role

Overview

- Methane a potent greenhouse gas.
  - Distant second to CO_2 in likely contribution to radiative forcing over the coming century (or over the past)
  - But short-life means that abatement gives relatively quick climate benefit that isn't captured by 100-year Global Warming Potential (GWP) index
- Natural Gas as a relatively low carbon, and generally quite clean energy source
  - Is it clean enough?
  - Applications, price & competitiveness, regional/global markets?
- CH_4 as an interesting chemical species that is a contributor to tropospheric ozone formation, ultimately oxidizes into CO_2.
  - Fossil CH_4 a (small) contributor to CO_2 concentrations.
  - Biogenic, if vegetation keeps going, is not a net contributor to atmospheric CO_2.
  - Tropospheric ozone is also a greenhouse substance
  - Lifetime of CH_4 depends on complex chemistry, levels of OH

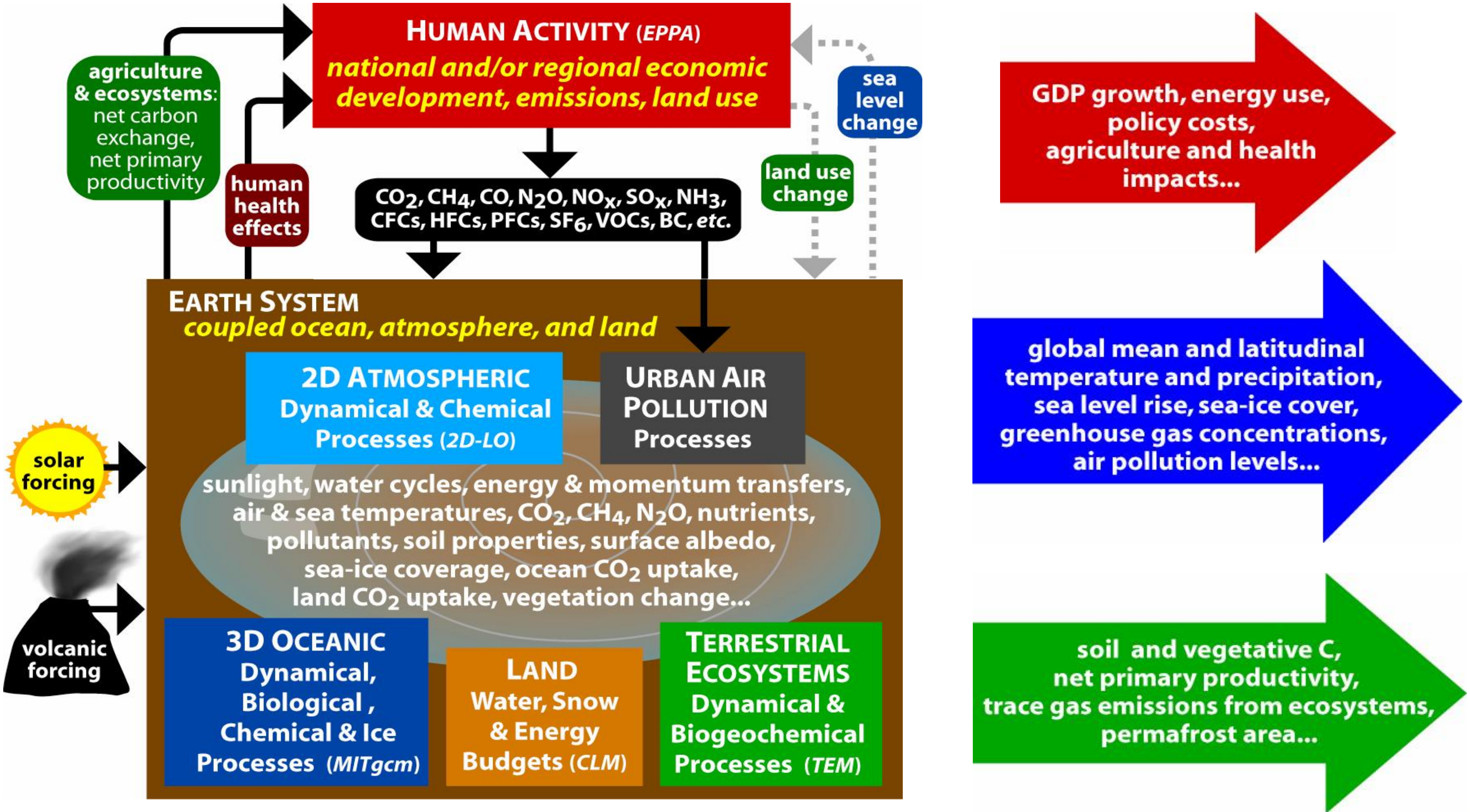
Climate Effects of Different Abatement Strategies

- Narrow and Deep *or* Broad and Shallow
  - Kyoto as a start to climate policy—?relatively deep cuts in CO_2 in a few countries?
  - Global methane policy, with a relatively low cost per ton carbon-equivalent or even benefit depending on ability to collect use as a fuel.

- Some test policies. Cases:

  1. *Ref*: no climate policy.
  2. *CH_4-only*: Global abatement of CH_4 below $15/tce
  3. *All Non-CO_2*: As (2), including N_2O, SF_6, PFCs, and HFCs.
  4. *Kyoto*: Kyoto with current participants (i.e without the US), no Clean Development Mechanism (CDM) credits.

MIT Integrated Global System Model (IGSM) Version 2



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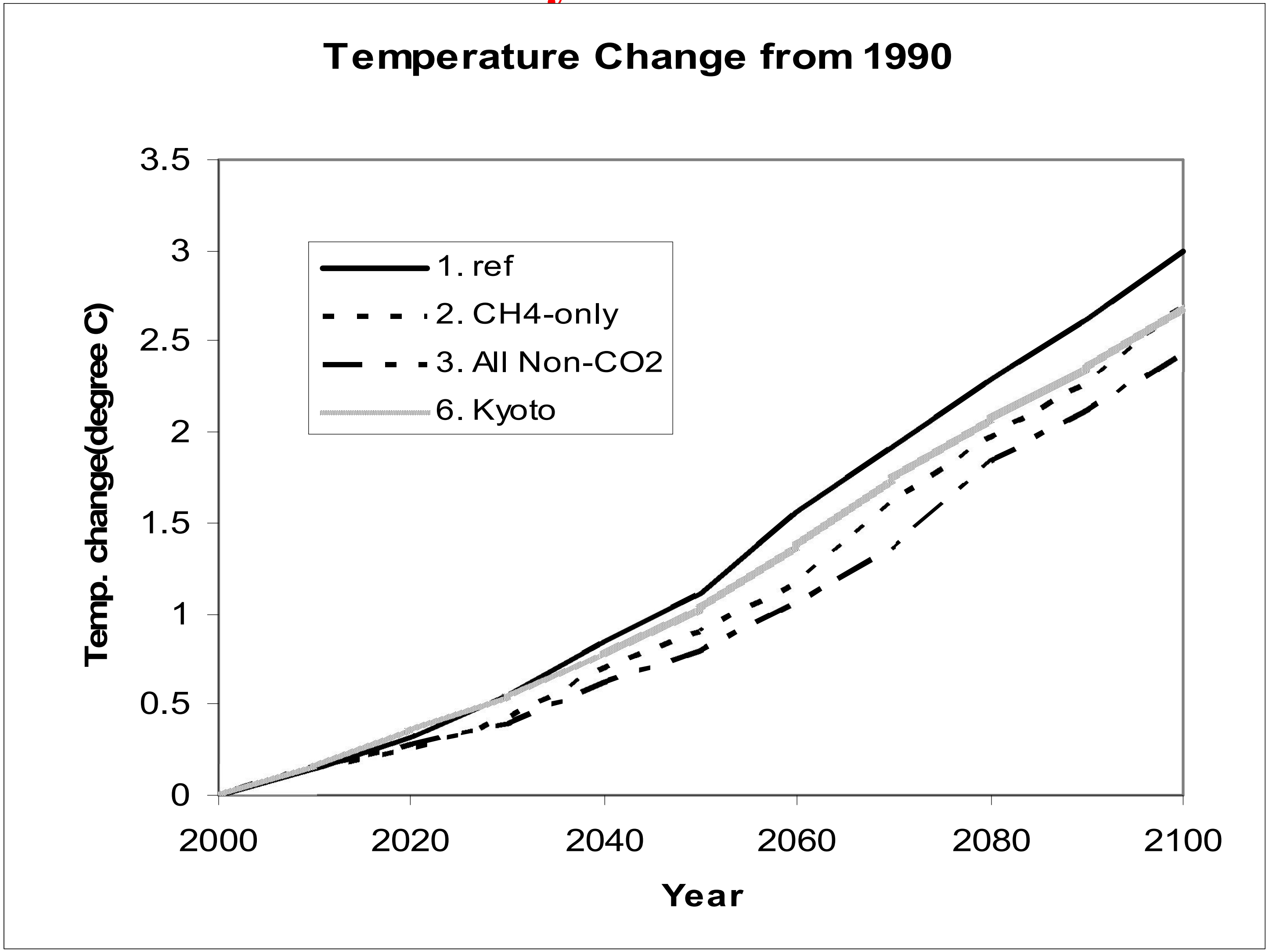
Decadal aver. mean surface T change from year 2000



Costs & Climate Benefits

Scenario	Case 2 CH_4-only	Case 3 All Non-CO_2	Case 6 Kyoto
NPV welfare loss (billions of 1997$)	~ 60	~180	~6,700
Temperature, °C , reduction from reference for 2090-2100 decade.	0.33	0.57	0.30

Reilly, J., M. Sarofim, S. Paltsev, R. Prinn, "The Role of Non-CO2 GHGs in Climate Policy: Analysis Using the MIT IGSM," Energy Journal (in press).

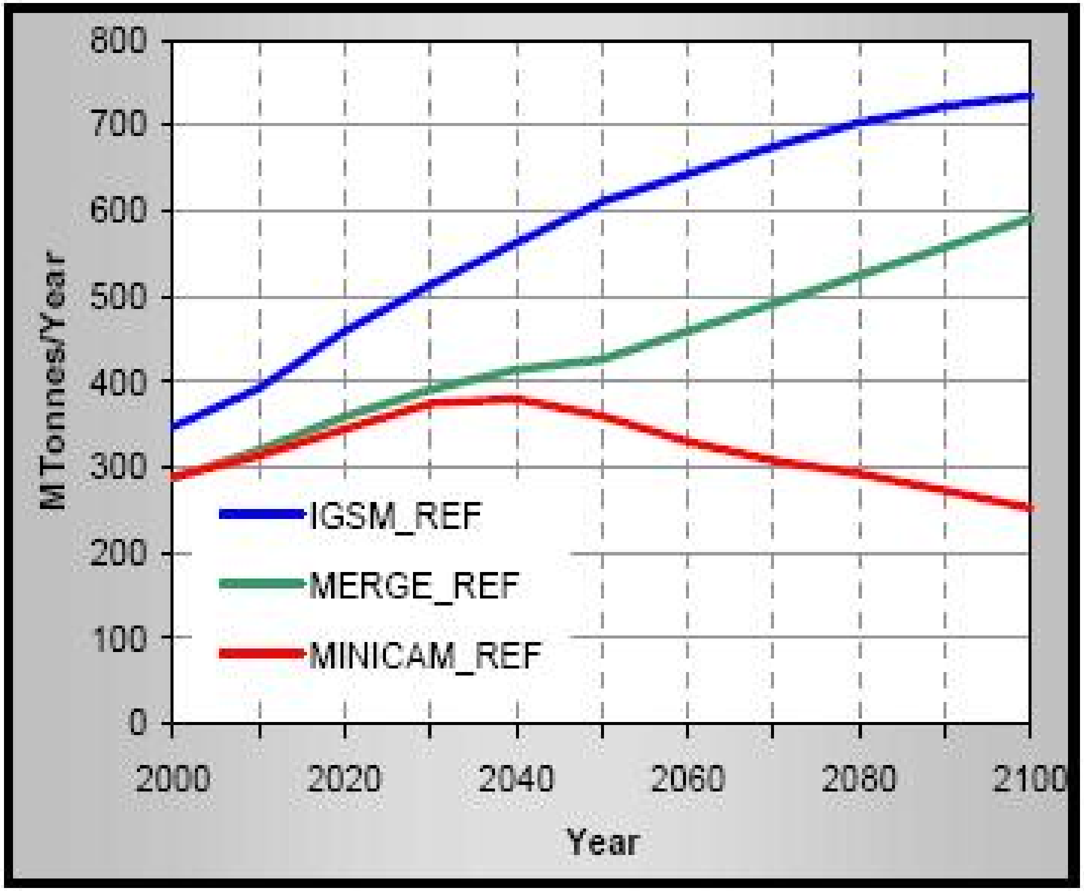
(or JP Report No. 114, Aug. 2004)

Policy Implications

- Methane, other GHGs just a start, but to failing to control these because we can't agree on CO_2 would seem to be a huge mistake.
  - Modest global agreement much more effective than tight cap limited to a few countries willing to accept such a cap.
  - Much of near term benefit from methane.
  - Focus on low cost abatement options by agreeing on price cap?
- Results depend on
  - Our reference emissions of non-CO_2 GHGs much higher than many forecasts so there is much more leverage.
  - Would it really be easier to get this modest global agreement in place?
  - Kyoto through CDM/JI already creating incentives for these reductions?

Difference in Reference Forecasts of Anthropogenic Emissions (US CCSP New Emissions Scenarios results)

CH_4 Emissions



Why different?

•Assumptions about whether methane will be collected in reference anyway because of price of natural gas.

•Also a major difference is uncertainty about natural vs anthropogenic emissions, particularly from rice production

Natural Gas as a Clean Abatement Option

- Does climate policy increase demand for gas, reduce demand, or leave it little changed?
  - Various modeling results suggest different roles for natural gas, depending on price/resource availability, time frame.
    - $100/tc = $.24/gallon of gasoline, $53/ton of coal, 1.72 mBtu of natural gas
    - In BTUs= $1.94/mBtu of gasoline, $2.58 mBtu of coal, or 1.72 mBtu of gas.
- Efficiency in use, other GHGs/upstream emissions an affect this comparison

Electricity

- Existing baseload coal may get 30-35% efficiency—NGCC could get 60%
  - per effective Btu: ~ CO_2 penalty is \$2.90 for gas; \$8.60 for coal, coal penalty almost 3 times natural gas.
- If ultra super critical pulverized coal can get 44% efficiency, more realistic NGCC is 54%
  - per effective Btu is: ~\$3.20 for gas and \$5.90 for coal, coal penalty less than 2 times.
- IGCC, hope to get 40% efficiency, but emit only 10% of the CO_2.
  - Per effective Btu is: ~\$0.65 compared with gas at \$2.90-\$3.20.
- Further depends on gas/coal prices and forecasts of them, and capital cost differences.

Natural Gas Vehicles?

Fuel Cycle Emissions, Grams per mile driven

	CO2	CH4	N2O	Total
Gasoline,	528	14	9	552
Gasoline-Direct Injection	465	13	9	487
Gasoline-Hybrid	386	11	9	406
CNG	392	38	5	434
CNG Hybrid	324	32	5	361
E85 Corn Ethanol	359	15	78	452
E85 Cellosic Ethanol	102	6	47	155
Diesel	426	11	5	442

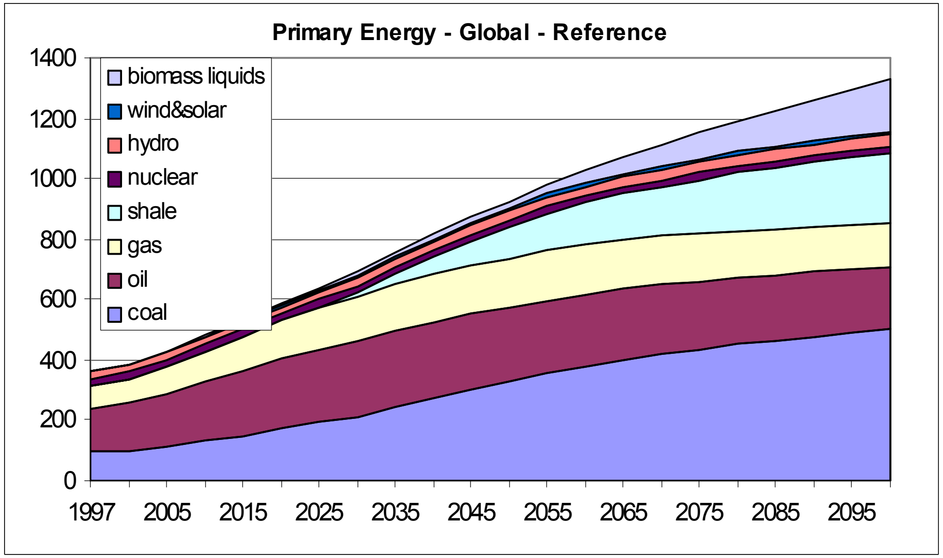
CNG is about 22% better than conventional gasoline vehicles

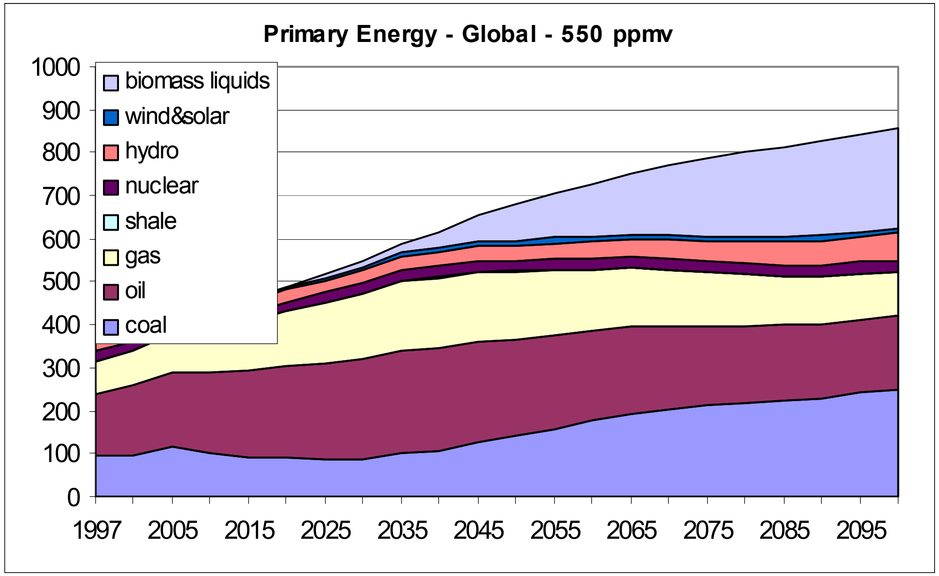
Only about 2% better than diesel, and 7% worse than a gasoline hybrid

Big winner for climate is E85 cellulosic ethanol—72% (65%) less than gasoline (CNG)

Source: N. Brinkman, M. Wang, T. Weber, T. Darlington, Well to Wheels Analysis…, Argonne Nat. Lab. http://www.transportation.anl.gov/pdfs/TA/339.pdf

Primary Energy Use, MIT Model, CCSP





Why not more gas in reference or policy?

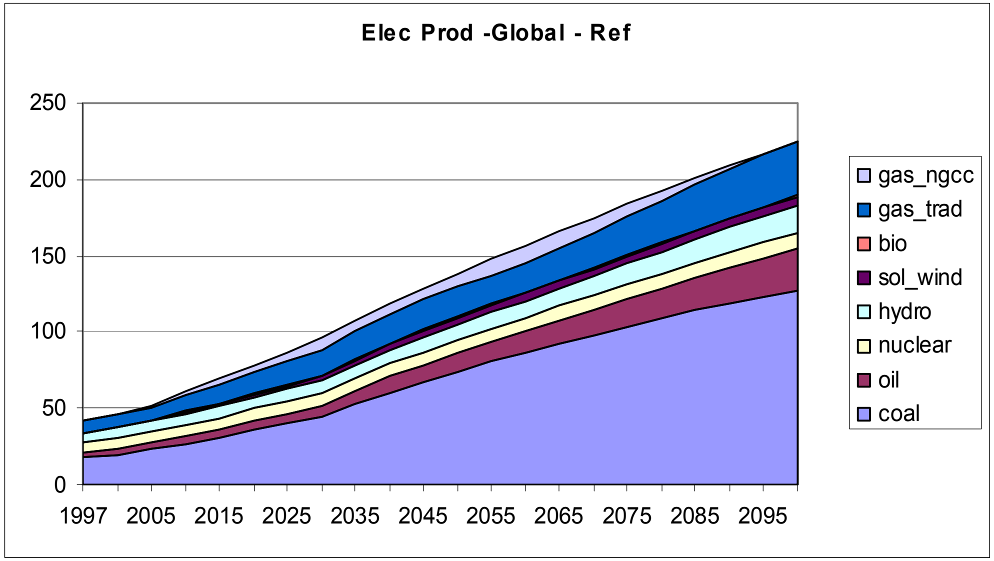
-Cumulative consumption in ref. is 15,500 EJ; in 550 ppmv about 14,000 EJ

-USGS Says total reserves and undiscovered resources are 14,400 EJ

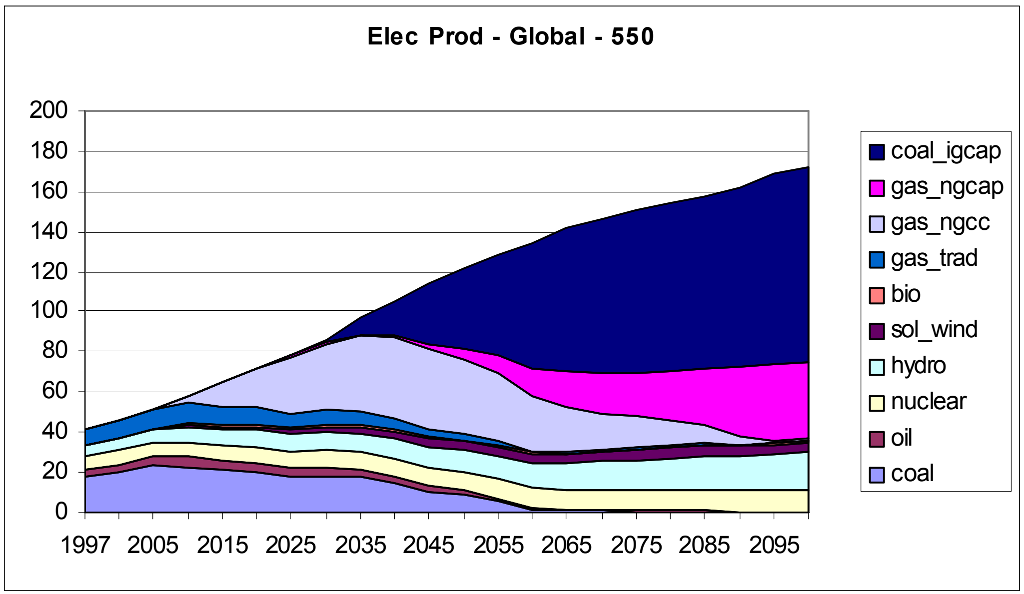
-We estimate higher resources ~ 19,000EJ but this becomes available only slowly/at high prices. In any case, nearly gone by end of the century.

Stabilization shifts some of that use forward, but natural gas not clean enough toward end of century without CCS.

Electricity Production by Fuel/Technology

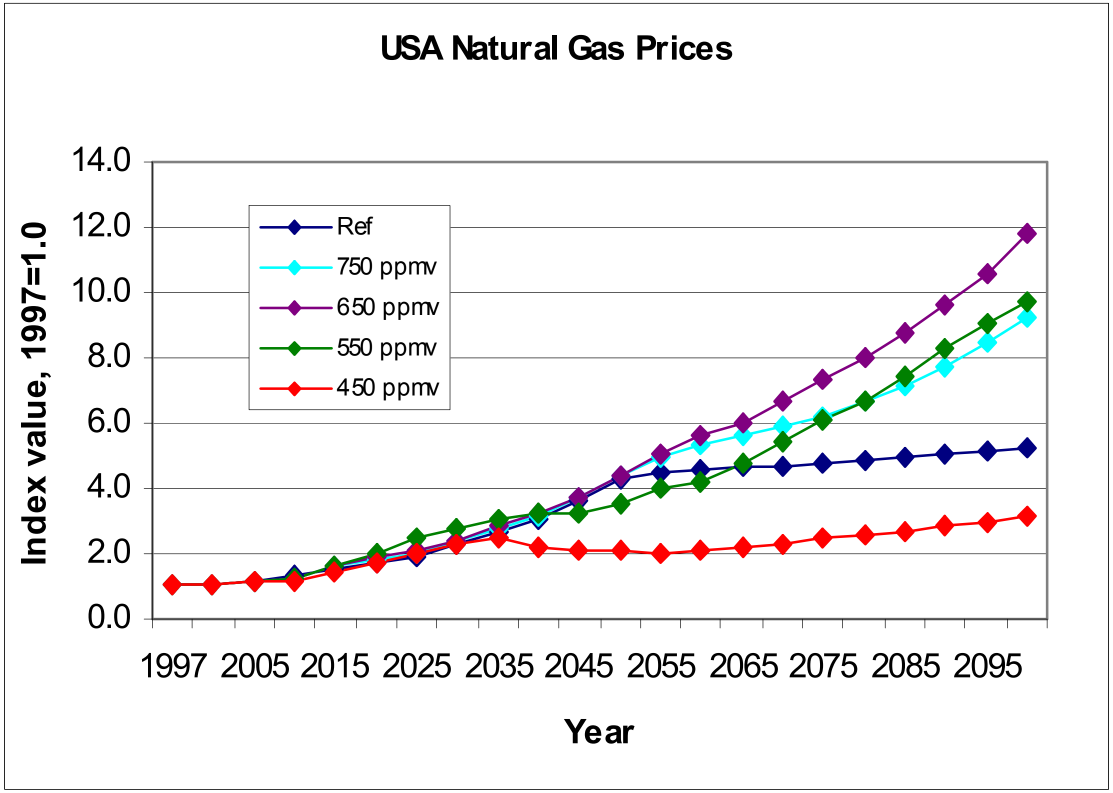


Without a strong climate policy, gas plays a traditional role as a complement to baseload generation technologies.



Under a policy that would achieve 550 ppm coal generation w/o CCS is gone by 2060. Gas plays a broader role as a baseload technology in the mid-term. Coal with CCS takes over much of baseload, and natural gas, if used, also must have CCS

Gas prices



Gas prices in reference up about 5x from 1997 (~$2.75 mBtu)

Higher price in 550-750 ppmv stabilization indicative of increased demand as an abatement option.

With tighter constraints (450 ppmv) gas is too carbon-intensive, demand decreases, price falls relative to reference.

But this price response makes gas more attractive with CCS compared with coal, and so gas is still used.

Natural Gas Role in the Future

- The main limit to gas is ultimately available resources.
  - Cumulative gas consumption through 2100 is about equal to USGS estimate of resources, with or without climate policy.
  - For a bigger role there must be much more resources than conventional estimates suggest.
- Climate policy increases the demand for gas (unless/until carbon limits become very tight), but the main effect is to shift more consumption to the nearer term through mid-century.
- As one approaches stabilization emissions limits become so binding that gas must include CCS.